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THE PERCEPTUAL FACTORS IN READING

A QUANTITATIVE STUDY OF THE PSYCHOLOGICAL PROCESSES INVOLVED IN WORD PERCEPTION

BY

FRANCIS MARION HAMILTON, PH.D.

New York Training School for Teachers

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INTRODUCTION

Almost every student is familiar with the recent rapid growth of knowledge in the psychology and physiology of reading. It is a rather common remark, however, that this growth is not equally distributed between the two phases of the problem, progress on the strictly psychological side having scarcely kept pace with that on the side of physiology. From the very nature of the case one could hardly expect it to be otherwise, since so many of the psychological problems depend for their solution on questions of physiology, and since methods of investigating problems of a purely psychological character, in so far as they are not identical with those of physiology, are naturally less well developed because of the peculiar complexity of many of these problems. It is not surprising, therefore, that the criticism should be made that as yet many of our psychological theories of reading rest on a much too slender basis of fact and that the problems demand further studies of a more specialized character, employing methods calculated to yield a larger amount of objective data which may be rigidly dealt with in accordance with recognized statistical methods. However much students of the problem may differ in regard to the value of current psychological theories, probably all will agree that the time is opportune for such specialized studies. At any rate it was in this belief that the present study was begun.

It was planned accordingly to limit the scope of the investigation to a single problem, and to rely as far as possible upon statistical methods for results. The particular problem chosen is the factors and processes involved in word perception as it takes place in adults in normal visual reading. As anticipated, however, this has turned out to be by no means a simple problem; in fact, it has proved to be much too comprehensive for a satisfactory treatment of its many phases within the brief scope of a study of this character. Attention has therefore been confined almost exclusively to those phases which seemed to lend themselves most readily to the statistical method and which thus gave promise of most immediate returns. This mode of procedure, to be sure, may tend to a certain incoherency and incompleteness of results but, in addition to the practical advantage mentioned, it should have a tendency to free the investigator from theoretical bias as far as that is possible.

On the whole, the results obtained are in fairly close agreement with those of certain other studies. As might be expected, however, this is not true in all cases, and the writer has thus been led to make some independent generalizations, which, are offered merely as tentative, and may be of value only as hypotheses for further investigation.

The following is a brief general statement of the plan of the study. The first part is devoted primarily to a study of context as a condition of word recognition. Experiments were made both by the method of rapid reading and by the method of short exposures. The material used in the first of the rapid reading experiments consisted of simple sentences, miscellaneous words, and consonants miscellaneously arranged. For the remainder of these experiments, longer selections of reading matter were broken up and arranged in different ways so that the different arrangements would contain varying amounts of the element of context. The difference in time required for reading the different arrangements was then taken as a measure of the value of the various contextual factors. For the short exposure experiments short sentences were broken up in the same manner as the above and presented in different forms, the amounts read per exposure in this case being taken as a measure of the value of the different elements of context contained within the sentence. In addition to these experiments which were devoted primarily to a study of context, all the experiments of the remaining part of the study have been so arranged as incidentally to test the value of this factor. The principal part of the investigation is found in the second division of the study which is concerned with the factors and processes of word perception, particularly those of a more habitual and automatic character. The method employed in these experiments was that of successive short exposures, an adaptation of the ordinary tachistoscopic method of reading designed to approximate as far as possible the normal reading process. The conclusion contains a brief summary of the results together with their more obvious applications and relations to other studies.

The writer's interest in this problem grew out of a brief unpublished study on "Higher Language Habits" which he carried on in the psychological laboratory of the University of Indiana under the direction of Professor W. L. Bryan. The problem was later definitely outlined and experimentation was continued in the psychological laboratory of the University of Chicago under the direction of Professor J. R. Angell. The final work of experimentation, and the calculation and writing up of results were done in the psychological laboratory of Columbia University under the direction of Professor J. McK. Cattell. Invaluable criticism and encouragement have been received from each of the above-named teachers, also from Professors J. A. Bergström of the University of Indiana, J B. Watson of the University of Chicago, E. L. Thorndike and R. S. Woodworth of Columbia University. About seventy different persons have kindly served as subject in the shorter experiments. Those who have served in the longer and more trying experiments and to whom the author is especially indebted are the following: Professor Angell, Mr. H. A. Carr, Mr. C. H. Bean, Miss

C. J. Weidensall, and Mrs. Hamilton. The latter has also assisted in the rather long and tedious work of calculation of results and in the preparation of manuscript.

It has not seemed best to set apart a special chapter for a formal discussion of the literature but to distribute this discussion throughout the text in connection with the various experiments.

CHAPTER I

THE INFLUENCE OF CONTEXT UPON THE PERCEPTION OF WORDS

I. Rapid Reading Experiments

Experiment I. Sentences, Words and Consonants. Practice Curve Method

The first experiment was carried on by the writer and consisted in reading at a maximum rate three sets of material of eleven selections each, made up respectively of (1) simple sentences, (2) simple words in miscellaneous order, and (3) consonants arranged miscellaneously. Each sentence or group of miscellaneous words or consonants consisted of twenty-five units, *i. e.*, twenty-five words or as many consonants as the case might be. All words used were monosyllabic and were chosen as nearly equal in difficulty as was possible *a priori.*

The experiment was carried on by the practice curve method and there was no restriction as to the particular method of reading except that the subject was careful to recognize distinctly every unit of the group. The time was taken with a stop-watch and was recorded immediately after each reading, together with the introspective observations. Each selection was read daily for a period of five or six days. Half of the experiments were made with the reading matter presented in the normal position, and the other half was presented upside down. The daily program was briefly as follows: (1) Beginning with the inverted matter, sentences first, the subject would read one sentence ten times, allowing thirty seconds for rest after each reading. (2) Allowing one minute for rest after the completion of this group, he then took up a selection from the sentences in normal position and read it ten times in the same way. (3) After one minute's rest, miscellaneous upside down words, (4) miscellaneous words in normal position, (5) miscellaneous consonants upside down, and (6) miscellaneous consonants in normal position were respectively taken up and disposed of, each in its turn in the same manner.

In the course of the experiment, then, upon the eleven different selections presented in each of the groups there was a total of 550 readings per group and in some cases more. 440 cases for each of the selections are tabulated below.

Table I exhibits the results for the rapid reading of sentences, miscellaneous words, and miscellaneous consonants in the normal position. The figures represent the average reading time per unit, *i. e.*, per word or per consonant in four stages of the practice, *i. e.*, (1) the first ten readings, (2) the second ten, (3) the third ten, (4) the fourth ten. This

is of course the equivalent of reading one selection of average difficulty 2750 times. On this basis each number in the table represents the average reading time per unit in its own group in the particular stage of practise where it is found.

TABLE I

The average reading time in seconds per word and per consonant in the rapid reading of sentences, miscellaneous words and consonants.

Eleven selections of twenty-five units each.

Normal position. Subject H. Practise curve method.

Readings.	Words in sentences.		Miscellaneous words.		Miscellaneous consonants.	
	M.	M.V.	M.	M.V.	M.	M.V.
1st ten	.1572	.0122	.2838	.0259	.2184	.0294
2nd ten	.1408	.0102	.2442	.0220	.1810	.0163
3rd ten	.1385	.0056	.2297	.0200	.1589	.0118
4th ten	.1352	.0042	.2026	.0144	.1421	.0114

Table II gives the same information for the rapid reading of sentences, miscellaneous words, and consonants upside down, the number of cases and the conditions being otherwise the same.

TABLE II

The average reading time in seconds per word and per consonant in the rapid reading of sentences, miscellaneous words, and consonants.

Eleven selections of twenty-five units each.

Inverted position. Subject H. Practise curve method.

Readings.	Words in sentences.		Miscellaneous words.		Miscellaneous consonants.	
	M.	M.V.	M.	M.V.	M.	M.V.
1st ten	.2595	.0312	.4135	.0902	.3419	.0386
2nd ten	.2132	.0175	.3700	.0530	.2805	.0335
3rd ten	.2020	.0108	.3086	.0273	.2469	.0256
4th ten	.1918	.0087	.2775	.0176	.2244	.0185

These tables show that for both the normal and the inverted positions the order of the ability is the same in all stages of the practise. The order of ability runs: (1) Words in sentences, (2) consonants,[1] and (3) miscellaneous words. The rate of improvement is much greater in both of the miscellaneous arrangements than in the sentences, the order

[1] This agrees with the results of Professor Cattell who found that the perception time for letters is very little shorter than for words. "Ueber die Zeit der Erkennung und Benennung," *Phil. Studien*, 2.

of improvement being as follows: (1) Miscellaneous consonants, (2) miscellaneous words, and (3) words in sentences.

This fact is further illustrated in Tables III and IV where miscellaneous consonants and miscellaneous words are compared in terms of per cents with words in sentence, considering the ability in the reading of words in sentences as a standard and assuming it to be one hundred per cent. The exact amount of this improvement from stage to stage is measured by the increase of the per cents in the columns of consonants and words.

TABLE III

Comparison in terms of per cents of ability for reading material in normal position, using ability in reading words in sentences as standard.

Readings.	Sentences.	Words.	Consonants.
1st ten	100	55.3	71.9
2nd ten	"	57.6	77.7
3rd ten	"	60.3	87.2
4th ten	"	66.7	95.1

TABLE IV

Comparison in terms of per cents of ability for reading inverted material, using ability in reading words in sentences as standard.

Readings.	Sentences.	Words.	Consonants
1st ten	100	62.7	75.8
2nd ten	"	57.6	76.0
3rd ten	"	65.4	81.8
4th ten	"	69.1	85.4

The shapes of the curves of practise differ for the different classes of material. This dissimilarity appears in Tables V and VI which exhibit the total gain for each group together with the distribution of this gain throughout the different stages of the practise. The record of the first ten readings is used here as a standard.

TABLE V

The total per cent of gain and its distribution throughout the practise for matter in normal position. Standard: first ten readings.

Readings.	Sentences.	Words.	Consonants.
From 1st to 2nd ten	11.	13.9	17.1
From 2nd to 3rd ten	.8	5.1	10.5
From 3rd to 4th ten	2.2	9.6	7.3
Total per cent of gain	14.	28.6	34.9

TABLE VI

The total per cent of gain and its distribution throughout the practise for matter in inverted position.

Standard: 1st ten readings.

Readings.	Sentences.	Words.	Consonants.
From 1st to 2nd ten	17.8	10.5	17.9
From 2nd to 3rd ten	4.3	14.8	9.8
From 3rd to 4th ten	3.9	7.5	4.4
Total per cent of gain	26.	32.8	31.1

These tables show that the distribution of gains is closely correlated with the total amount of gain. The form of distribution may be stated as follows:

The less the total amount of gain in a given series of trials, the more that gain tends to be concentrated in the early part of the practise. Put conversely in terms of habit, the principle may be formulated thus: the farther the method of reading is removed from the habitual, the greater is the total amount of gain in a given number of trials and the more evenly are these gains distributed throughout the period of practise, *i. e.*, the more gradual is the curve of improvement. For example, in the reading of sentences, from sixty to eighty per cent of the total gain appears in the first half of the curve.

Besides the intrinsic difference in complexity of different classes of material for the purposes of rapid reading, the experiments show that there is a considerable difference between different selections of the same class. Although the selections within a given group were judged *a priori* to be equal in difficulty, there is as a matter of fact a more or less permanent disparity between such materials. The existence of this disparity does not, however, invalidate the conclusions already reached. It rather indicates the unfitness of such material for wide practical use in experimentation, because of the large number of experiments necessary to compensate for this variable element and the consequent difficulty in securing subjects who could devote the requisite amount of time to it. In order, therefore, to secure data from a larger number of individuals, certain modifications of material were introduced, though the general method and purpose of the experiment remained the same.

To approximate as nearly as possible the content of normal reading matter, the material chosen for the next three series of experiments consists of well unified and intrinsically interesting paragraphs. To facilitate calculation, they are limited to exactly one hundred words each. None but common words were used, and these were of as great a variety as possible. The material was read in four different arrange-

ments which may be designated as: (1) Whole paragraphs, (2) miscellaneous sentences, (3) miscellaneous phrases, and (4) miscellaneous words; that is, (1) each paragraph was read as a unit, thus giving full influence of paragraph context, (2) the paragraph context was destroyed by arranging miscellaneously the sentences, whose context remained, and (3) the paragraph and sentence contexts were both destroyed and only that of the phrase kept intact. This was done by rearranging miscellaneously all the phrases of the entire paragraph, retaining the capitals and other marks of punctuation as ear-marks of sentence and paragraph structure, and (4) all the words of the paragraph were juggled into miscellaneous order, with the punctuation marks as the only semblance of context left. In short, the attempt was to secure as nearly a perfect context as possible, step by step to reduce it, and at each step to find the exact minimum reading time. Obviously, it is impossible to remove entirely the element of context, for there will still remain an ideal context as long as the word or character has any definite meaning, nor on the other hand is it possible, save theoretically, to obtain a context which is absolutely perfect.

Following is a sample of these paragraphs, arranged in the four different ways. Eleven different sets, similar to the sample, were used.

PARAGRAPH FORM

A great many centuries ago, long before printed books and newspapers were known, there was an age of great intellectual darkness and confusion. This dark period was the separating era between ancient and modern civilizations. Justice and liberty were unknown terms in those days. The world's chief occupation was quarreling and fighting. A man's power was determined by his physical strength and by the lands he possessed. From the poor peasant to the king no person was in the least secure. Plots and insurrections disturbed every nation from within, while from without frequent invasions of barbarian hordes devastated the lands.

MISCELLANEOUS SENTENCE FORM

Plots and insurrections disturbed every nation from within, while from without frequent invasions of barbarian hordes devastated the lands. The world's chief occupation was quarreling and fighting. This dark period was the separating era between ancient and modern civilizations. A man's power was determined by his physical strength and by the lands he possessed. A great many centuries ago, long before printed books and newspapers were known, there was an age of great intellectual darkness and confusion. From the poor peasant to the king, no person was in the least secure. Justice and liberty were unknown terms in those days.

MISCELLANEOUS PHRASE FORM

Plots and insurrections by his physical strength, while from without frequent invasions between ancient and modern civilizations. The world's chief occupation of barbarous hordes disturbed every nation from within, and by the lands he possessed. A man's power was determined and newspapers were known, devastated the lands. From the poor peasant to the king long before printed books and confusion. Justice and liberty were unknown terms was quarreling

and fighting. A great many centuries ago, was the separating era no person was in the least secure. This dark period there was an age of great intellectual darkness in those days.

MISCELLANEOUS WORD FORM

A and every disturbed of devastated between while before ancient within and insurrections nation liberty from possessed. Justice newspapers by and man's the his were and barbarous from was and modern there person lands. From was physical unknown printed hordes the quarreling and without in were was intellectual long days. The separating books strength, peasant the was no of age, least great poor many darkness power era the was confusion. A centuries term determined the those occupation great to an fighting. This and age king known, chief world's by lands in secure. Plots the dark he frequent periods invasions civilizations.

In carrying out the experiment the different arrangements of the words were alternated systematically so as to avoid giving any one arrangement an undue advantage over the others. Three different classes of persons were tested: (1) Public school children from nine to twelve years of age; (2) educated adults, advanced university students; (3) trained psychologists, graduate students and teachers.

Experiment 2. *Reading of Paragraphs, Sentences, Phrases and Words by Children*

The children were practised individually, each child being given ten trials, one trial each day for ten days. The material was printed in good, clear ten point type and the reading was done orally at a maximum rate. The time of each reading was taken by means of a stop-watch. In case a child hesitated unduly on a word, he was prompted by the experimenter. This difficulty, however, seldom occurred and gradually disappeared after a few trials. Table VII gives the average reading time per word for eight individuals in the four different arrangements of the material.

TABLE VII

The average reading time in seconds per word for children from nine to twelve years of age.

	Paragraph.	Sentences.	Phrases.	Words.
Mean	.429	.456	.466	.660
M. V.	.047	.047	.041	.078

With two or three minor exceptions the reading time throughout was diminished consistently with the increasing organization of the material. Representing these records in terms of per cents by using the reading time in the paragraph arrangement as a standard, we have a more direct comparison of the reading abilities in these four arrangements of the material.

TABLE VIII

Comparison in per cents of the quickness of children in reading four arrangements of words, using the speed of reading the paragraph as a standard.

Paragraph.	Sentences.	Phrases.	Words.
100	94	92	65

Experiment 3. *Reading of Paragraphs, Sentences, Phrases and Words by Adults*

The next test was made with forty-one students of an advanced class in pedagogy. Each member of the class was provided with a typewritten copy of the four different arrangements of the material described above, and upon a signal given by the conductor each person read as much as possible in ten seconds. Two trials were given but, as there were a number of errors in the first trial due to lack of familiarity with the experiment, the second trial was taken as the best measure of the rapid reading ability of the class. Instructions were given to read as rapidly and accurately as possible, each using his own method in the reading. Table IX gives in seconds the average minimum reading time per word for the forty-one subjects in each of the four arrangements of the material.

TABLE IX

The average minimum reading time per word for advanced university students.

	Paragraph.	Sentences.	Phrases.	Words.
Mean	.1294	.1324	.1562	.2057
M. V.	.0176	.0190	.0231	.0392

As in the case of the children the rate of reading for adults decreased with a decreasing amount of organization of material, though the amount of this decrease is greater. Table X compares these records directly in terms of per cents by using the reading time of the paragraph arrangement as a standard.

TABLE X

Comparison of the reading ability of adults in terms of per cents, using the speed of reading the paragraph as a standard.

Paragraph.	Sentences.	Phrases.	Words.
100	97.7	82.8	62.8

The large absolute difference between the reading times of children and adults, shown by a comparison of Tables VII and IX, is not to be accounted for wholly on the basis of maturity, for it must be remembered that the children were limited to oral reading of printed matter and that the adults read typewritten material silently. The individual differences are considerably greater among the adults than among the children, though these differences for the adults would doubtless have been reduced by an equal amount of practise.

Experiment 4. Reading of Paragraphs, Sentences, Phrases and Words by Psychologists

The psychologists practiced individually and were given one trial at each of several different one hundred word selections, arranged in the four different ways already described. Table XI gives in seconds the average minimum time required per word for the selections read, together with the mean variations for each individual in reading different selections.

TABLE XI

The average minimum reading time in seconds per word for experienced psychologists.

Subject.	Paragraph.		Sentences.		Phrases.		Words.		Number of words read.
	M.	M.V.	M.	M.V.	M.	M.V.	M.	M.V.	
A.	.137	.008	.159	.009	.195	.011	.272	.008	500
W.	.201	.043	.254	.033	.248	.030	.349	.051	700
B.	.243	.028	.252	.027	.324	.021	.433	.063	800
C.	.185	.019	.228	.038	.241	.033	.338	.016	700

As a check on the accuracy of the reading, each person was asked after each reading, to give all the facts he could remember of what he had read. In the case of miscellaneous phrases and words, this report was necessarily quite general, consisting of a description in a general way of the universe of thought suggested by the reading. This condition may partly explain the generally longer reading times of Table XI over those of Table IX, though it is safe to assume that the greater scientific interest and maturity of the subjects whose records are found in Table XI would tend to produce greater accuracy and a consequent increase of the reading time.

Comparing in per cents each individual's record for the reading of sentences, phrases, and words with his record in the paragraph as a standard, we get the results in Table XII.

TABLE XII

Comparison in per cents of reading ability in paragraphs, sentences, phrases, and words for adults (psychologists) using the paragraph as a standard.

Subject.	Paragraphs.	Sentences.	Phrases.	Words.
A.	100	86.1	70.2	50.3
W.	"	79.1	81.0	57.5
B.	"	96.4	75.0	56.1
C.	"	81.1	76.7	54.7

This table shows that only about half as much can be read in the miscellaneous word arrangement as in the paragraph, about three-fourths as much in the phrase arrangement, and six-sevenths as much in the miscellaneous sentences. The first of these results agrees with the conclusion of Professor Cattell[1] who found that words and letters out of context require approximately twice as much time for recognition as those in context.

It may be concluded from these experiments that what we call context is a complex affair, and that each of its constituent elements, *i. e.*, the phrase, the sentence, the paragraph, etc., has presumably a definite measurable value as a factor in word recognition. The influence of these contextual factors varies with different individuals, with maturity, with practise, and with different selections of reading matter, the latter varying directly as the perfection of the context.

Some of the introspective observations are of sufficient interest to deserve mention. For example, in the reading of miscellaneous words and consonants, the writer found that grouping the units had the effect of increasing the rate, the maximum speed being attained by groups of three. Of twenty-five subjects tested on this point all but one found the same result. The advantage of such grouping was less marked, however, in the early stages of practice, particularly if the units or their order were unusually strange or difficult.

Certain other devices were often found by the writer to assist in increasing the rate, and these held for all the arrangements of the material. For instance, silent reading usually brought higher speed than oral reading. But if, as it sometimes happened, the reader reached a dead level of practise by this method, he was usually able to break the spell by introducing oral expression for a few trials. Another means which was often effective under these circumstances was to run over in the mind a new and faster rhythm just before beginning to read. Immediately after making a new record in this way there would be a period of struggle which lasted for a time, until the old rhythm habit was en-

[1] "Ueber die Zeit der Erkennung und Benennung" *Phil. Studien*, 2.

tirely broken up and displaced by the new. But as soon as a new pace had been set by one method, it was as a rule easy to duplicate it by the other.

Another fact commented upon by a number of subjects was the relatively large amount of superfluous imagery and the large number of irrelevant associations, which accompanied the reading of miscellaneous matter. In the reading of imperfect contexts greater effort was required and subjects described such reading as distinctly unpleasurable.

In the actual perception of words or word groups, two phases of attention movement, which were described by subjects, seemed to occupy separate moments in consciousness. The phase which appeared first, as a rule, was a movement predominantly of the synthetic type, by means of which a word or group of words was fixed upon as a whole with little if any consciousness of details. The second phase consisted of a movement of the analytic type, by means of which the details of the group were identified as far as necessary and exact meanings determined. A peculiar exception to the above order was occasionally noted, in which the analytic phase seemed to precede and the details to arise independent of the group. For the moment all effort to effect a fusion would be thwarted and then suddenly the elements would shoot together involuntarily, and group themselves in a logical arrangement.

It was of course in these more automatic activities that subjects encountered the greatest difficulty in making the analysis. There could be but little certainty in determining the detailed processes by means of which word perception is accomplished, since the method did not yield any great amount of objective data which could be dealt with statistically and so warrant the formulation of a definite theory.

II. Reading by Short Exposures

The next step in the study therefore was to employ a method more refined, farther removed from the ordinary method of perceiving words, and so better calculated to yield such objective data. Fortunately, the tachistoscopic method has been found to be effective for this purpose and is one which approximates the conditions of normal reading sufficiently to warrant the application of data, thus obtained, to many of the problems of word perception.[1]

[1] Professor Dodge (*Psych. Bul.*, Vol. II., No. 6, p. 20) has expressed doubt as to whether "the results of minimum exposure and threshold stimulation may be transferred bodily to the processes of normal reading without doing violence to the facts." It is not contended here that the results of tachistoscopic reading, whatever the length of exposure, can be indiscriminately applied to the normal reading process. Surely no one would seriously contend that the strictly quantitative aspect of such results could be thus applied.

The observation of Lamare and Javal[1] that in reading, the eyes do not move by continuous sweeps across the page, but by a series of short jerky movements ("par saccades"), has recently been scientifically confirmed by a number of investigators.[2] Moreover, it has been determined that during these short movements of the eye the retinal impressions received are of little or no consequence in the actual process of reading.[3] Between these short movements there is a period when the eyes are comparatively at rest. This period, commonly known as the "reading pause," has a duration which varies widely with different individuals and also with the same individual in reading different materials, but with the ordinary reader it probably averages about one-fifth or one-third of a second.[4]

From these facts of eye movement, it is evident that only those processes of word perception yield to the tachistoscopic method of study which are found within this short period when the eyes are at rest. To facilitate such study, various students of the problem have found it necessary to keep the length of exposure less than the length of the shortest reading pause in normal reading. It remains to adjust this method to the conditions of the problem and, if possible, to make a somewhat more precise and extended analysis than has heretofore been attempted.

Experiment 5. Tachistoscopic Reading of Short Sentences, Phrases and Words by Psychologists

The next experiment is a brief preliminary study, by the method of short exposures, of the ability to read the same words arranged in three different forms, *viz.*, sentences, miscellaneous phrases, and miscellaneous words. The main purpose of the experiment was to make a comparison of the reading ability under these conditions as measured by (1) the amounts read per exposure, (2) the variation of the amounts read from exposure to exposure, (3) the distribution of the amounts read over the area of clear vision. Incidentally, the experiment was

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[1] *Annales d'Oculistique*, **82**, 252, 1879 (Note).

[2] Notably the following: (*a*) Erdmann and Dodge: *Psychologische Untersuchungen über das Lesen auf Experimenteller Grundlage*, Halle, 1898. (*b*) Huey: "The Psych. and Physiol. of Reading," *Am. J. Psych.*, **10**, **11**, and **12**. (*c*) Dearborn: "The Psychology of Reading," *Arch. of Philos., Psych., and Sci. Methods*, No. 4.

[3] Professor Cattell first called attention to this problem in a study "On Relations of Time and Space in Vision," *Psych. Rev.*, **7**. Professor Dodge expressed the view that it was due to the fusion of the impressions received during eye movement, "Visual Perception during Eye Movement," *Psych. Rev.*, **7**. Professor Holt believes that it is the result of central anesthesia, *Harvard Psychological Studies*, Vol. 1.

[4] See Huey and Dearborn, *Op. Cit.*

intended to test the introspective observations made during the experiments by the method of rapid reading in reference to the movements of the attention and the more automatic processes in word recognition.

The apparatus used consisted of a modified form of the Cattell fall-screen, adjusted so as to expose the reading matter for a period of .021 second. The material to be read was typewritten and pasted on cards so that at the moment of exposure the geometrical middle of the reading matter would coincide with the middle of the slot in the exposure screen. The size of the objective groups varied from four to six words, containing a total of about fourteen to nineteen letters and covering a space on the card of forty-five to sixty millimeters in length. The experiments were carried on in a dark room in order to secure uniformity in light conditions which was not otherwise possible in the rooms where the experiments were conducted. The light was a sixteen candle-power electric bulb which was placed to the left on a level with the slot and so shaded as to avoid any disturbance from the glare. Before beginning any series of experiments, subjects were allowed a few minutes for adaptation to the novel light conditions and were given a few preliminary tests to satisfy themselves that the adaptation was sufficiently complete.

Five subjects were tested in this experiment, all being trained psychologists with the exception of one who was a college graduate and a high school teacher of English. This subject also had a general knowledge of psychology and of psychological methods.

The manner of conducting the experiments was the following: subjects were asked to focus for the exact middle point of the slot, *i. e.*, the place where the middle point of the reading matter was to appear at the time of exposure. Each person was allowed to choose his own normal distance for reading. As an aid in directing the focus, a fine black thread was stretched horizontally in front of the screen on a level with the line of words to be read. At right angles to this thread and intersecting it at the middle point was drawn a black line on the gray screen which covered the words, the fixation point being the point of intersection of the thread and the line. Each card was exposed but once, and after the exposure the subject gave out orally all that was read, stating the various degrees of certainty for each word or part of word, and otherwise describing the impressions together with any subjective phenomena that might be interesting or significant.

This report was recorded by the experimenter. In conducting the experiment, care was taken to alternate the exposures of the various arrangements of the material in order to avoid favoring any one above another. The smallest number of experiments for any individual was thirty-five and the highest number ninety-three.

Table XIII. gives the absolute amounts read per exposure by the different subjects in each of the different arrangements of the material. The figures represent millimeters.

TABLE XIII

The amount in millimeters, of words arranged in sentences, miscellaneous phrases, miscellaneous words, read at a single exposure of .021 second.

Subject.	Sentences.		Phrases.		Words.	
	M.	M.V.	M.	M.V.	M.	M.V.
A.	41.6	10.3	34.5	10.5	12.9	6.6
M.	23.6	11.1	17.6	8.0	13.1	5.8
W.	33.1	10.7	27.7	10.1	16.3	7.1
B.	25.4	7.8	23.4	4.1	13.1	6.5
C.	42.8	6.6	34.9	10.4	23.6	12.3

These results show a marked advantage for the sentences over the phrase arrangements, and a still greater advantage for the phrase arrangements over those of miscellaneous words. This is shown both by the means and the mean variations. In all cases the absolute size of the means, and in most cases the relative size of the mean variations are larger as the context is more complete. The averages representing the abilities in reading these different arrangements of the material are compared directly in terms of per cents. in Table XIV, using the ability in reading words in sentences as a standard or one hundred per cent.

TABLE XIV

Comparison in terms of per cents of the reading abilities for words in sentences, miscellaneous phrases, and miscellaneous words.

Subject.	Sentences.	Phrases.	Words.
A.	100	71.5	29.4
M.	"	74.3	55.2
W.	"	79.2	46.9
B.	"	90.0	50.4
C.	"	80.4	28.3

These remarkable differences would probably be reduced with practise, though they are significant as representing the comparative initial difficulty of words when presented in these different forms. The results suggest that the higher logical processes enter into and reinforce the processes of perception to a greater extent than we are accustomed to suppose and that in so far as tachistoscopic experiments hitherto have not taken these factors sufficiently into account, we are liable

to considerable error in applying their results to the processes of word perception in normal reading.

The great influence of context is also shown by the relative size of the variabilities. This may be calculated by dividing the averages into the variabilities or preferably into the square roots of the variabilities. We will not take the space for recording these data, but the comparison shows with two very slight exceptions that the relative variability increases very rapidly with a decrease of context.

In regard to the distribution of the portions read over the clear field of vision, the results show certain differences in the different arrangements of the material, but not such as are easily interpreted as due to the varying amounts of the contextual factor. Table XV shows the per cent of all that was read (1) to the left and (2) to the right of fixation.

TABLE XV

The per cent of all that was read to the left and to the right of the fixation point.

Subject.	Sentences.		Phrases.		Words.	
	Left.	Right.	Left.	Right.	Left.	Right.
A.	50.0	50.0	50.3	49.7	53.3	46.7
M.	47.2	52.8	58.6	41.4	55.1	44.9
W.	43.4	56.6	47.8	52.2	38.3	61.7
B.	73.0	27.0	82.1	17.9	66.3	33.7
C.	47.5	52.5	42.3	57.7	41.5	58.5

The peculiar shifts from one side of the field to the other which are noticed in certain cases may be accounted for by the position of certain words which happened to be specially familiar or interesting to the subject or possibly more objectively prominent. Accident would account for this result only if the number of experiments was too small to eliminate the effect of chance in attending to one side or the other. But where the subject habitually read to the same side as was true in the case of B., it is quite possible that, though the subject may have fixated as per instructions, he unconsciously attended more to one side of the point of fixation than to the other. This phenomenon is one of interest and deserves special study on its own account, but as it does not immediately concern my main problem I shall not pursue the investigation any further at this point.

It should be remarked in passing that in this experiment subjects were often able to describe the process of word perception with more or less detail. At almost every exposure one or more of the words were only partially perceived, and in such cases the character and the order of the phenomena were readily detected. These descriptions tended

to confirm the introspective reports given in the rapid reading experiments, but it is not necessary to present the data here because the next experiment which we have to describe will afford a larger number of cases of the same general character which will be tabulated and discussed fully.

CHAPTER II

THE FACTORS AND PROCESSES OF WORD PERCEPTION

I. SIZE, FORM AND ELEMENTS OF THE VISUAL READING FIELD

A valuable result of the foregoing experiment was that it suggested certain modifications of the method which seemed to approximate more nearly the conditions of normal word perception. The principal modification consisted in the use of longer selections of reading matter including three different arrangements, the paragraph, miscellaneous phrases, and miscellaneous words, which were read by successive exposures in such a way as to render the procedure as nearly as possible similar to the successive reading pauses in normal reading.

As suggested above we are doubtless in danger of misrepresenting the facts if we attempt to apply indiscriminately the results of tachistoscopic studies to the ordinary reading process, and my experiments thus far indicate that the artificiality of such results is augmented more or less wherever the experiments have been confined to the reading of materials with little or no contextual connection. Moreover, it is the supposition of the next experiment that this artificial character of results may be further avoided by employing a method of exposure more closely approximating the method of procedure in ordinary reading. The opportunity for this improvement is afforded by the fact that in ordinary reading not all the impressions received during a reading pause are interpreted correctly at that moment. The vague, indefinite impressions of the right-hand margin of one reading pause become therefore, the correctly interpreted impressions of the next, and so on, which is the equivalent of two exposures by the tachistoscopic method, the first of which is in the margin, the second in the most distinct portion of the visual field.

Experiment 6. Tachistoscopic Reading by Successive Exposures (Psychologists)

In the following experiment I have attempted to incorporate both of these conditions as far as the tachistoscopic method will allow. As in the second experiment in rapid reading, well unified paragraphs were selected. These also contained one hundred words each and were presented in the three different arrangements used in the above experiment. This material was then typewritten and the sentences or groups were cut and pasted on long strips of cardboard so that the line of words would be maintained at a constant level in the slot of the exposure screen.

The reading was then carried on by exposing this material from left to right, section by section, so that no part which was correctly

read was exposed a second time, except in the few cases where the order was reported wrongly, or where the subject overlooked or misread a word in the left portion of the field. In these cases a second exposure or even more, if necessary, was given. As a get-ready signal the experimenter spoke out the words read correctly in the previous exposure. Immediately after the exposure, the subject read aloud all the words he saw distinctly, also all he saw less distinctly, stating the degree of certainty in each case. Besides the portions read correctly, subjects were asked to describe all other appearances as accurately as possible. For example they would report their estimate of the total number of words exposed and their recollections of the form, size, shape, number of letters, etc., of each word. They also reported any isolated letters or groups of letters clearly seen whether in the clear or the obscure portion of the field. This report the experimenter recorded fully as per sample which follows:

Subject A, Paragraph 5, Sentences I and II.

"A baby beaver was caught and given to a gentleman as a pet. Beavers, you must understand, build dams in which they can make their houses."

Record.

Exposures.

I. 1. A (heavy?)
2. baby - - - -5–6.
3. beaver - - - -?
4. was (crawling?)
5. caught - - - -3–4.
6. and given
7. to a gentleman (Only form of last seen.)
8. as a pet.

II. 1. Beavers (the)
2. you—4.
3. must (acknowledge?) (Expected "acknowledge.")
4. understand (-anticipation.)
5. build dams (got "dams" from help of context.)
6. in which—4.
7. they can
8. make - - - -5–6.
9. their (homes.) (-anticipation.)
10. houses. (Preferred "homes," saw "h- -n? - -s" and interpreted it as "houses.")

The various items in this record were tabulated under the following headings: distinct, doubtful, correct form, incorrect form, no form, partial substitutions, total substitutions, omissions, prominent letters, positive anticipation, negative anticipation, memory, after image, suggested word, attention, delayed recognition, lapse, etc., etc.

Under distinct, doubtful, etc., the amount read was recorded in words, letters, millimeters. Under prominent letters, record was made of initial, middle, and final letters, etc. The light conditions and the

precautions taken for adaptation were the same as those in the previous experiment. Each subject was allowed, as in the former case, to select his own normal reading distance. As a guide in securing proper focus, faint black lines were drawn on the gray screen, showing the exact position of the words. One line drawn vertically showed the extreme left-hand margin or beginning point of the reading material, another faint dotted line drawn horizontally showed the exact level of the line of words to be read. With these limits defined, the subject was allowed to choose his own exact fixation point, and with a very few preliminary trials was able to find a point which for him was most satisfactory. Subjects found this device for directing the fixation more advantageous than that used in the previous experiment and, so long as these lines were quite faint, they did not experience any additional distraction on account of the lines moving with the screen at the time of exposure.

The same subjects were employed as in the previous experiment, all but one being, as stated above, psychological observers of considerable maturity. In addition to these subjects the writer, H., read a selection prepared by another person. The results of his experiment appear in the table, but they are not directly comparable with the others since the material read was not the same. The largest number of rates of exposure was used with subjects A. and M. as will appear in the table. The highest exposure time was .044 second, the lowest was .006 second, the other rates being distributed between these two extremes. The various arrangements of the material were alternated as in previous tests, but the selections were presented in the order tabulated below, beginning with the highest exposure time and then reducing the time, step by step, until the lowest time of exposure was reached. All subjects whose records show the employment of any given rate, say .044 second, read the same material at this rate. Thus the results for all subjects except H., whose irregularity was explained above, are entirely comparable in every respect. For convenience in comparison, the various paragraphs are numbered 1, 2, 3, etc. Most of the tables which follow in this study have been compiled from the records of these experiments.

Table XVI is the first of the series. It sets forth in millimeters the average amounts read correctly per exposure for the different subjects, and for the different rates in all arrangements of the material. The values of these figures can be transmuted into terms of letters by dividing the number of millimeters by 3.5 or into words by dividing the number of millimeters by 14, the average width of letters being about three and one-half millimeters, and the average size of words about four letters.

TABLE XVI

The amounts read correctly per exposure in millimeters.[1]

Subject.	Sel.	Rate.	Paragraphs.		Phrases.		Words.	
			M.	M.V.	M.	M.V.	M.	M.V.
A.	1.	.044	32.3	6.8	31.0	9.4	25.6	6.5
	2.	.016	23.6	7.0	24.5	6.6	20.3	5.6
	3.	.013	24.6	6.4	25.1	5.8	22.5	6.1
	4.	.010	28.0	6.0	26.0	7.4	19.8	5.8
	5.	.007	19.8	6.3	18.4	5.2	15.9	4.4
	6.	.006	16.0	5.8	15.6	5.4	14.2	4.8
M.	1.	.044	29.9	10.9	28.3	9.8	21.5	7.4
	2.	.016	20.7	8.2	18.1	7.3	15.9	5.8
	3.	.013	22.9	7.1	19.0	6.2	16.6	5.7
	4.	.010	22.3	7.0	20.1	7.3	19.8	6.9
	5.	.007	22.2	8.2	16.1	5.8	14.4	4.9
W.	1.	.044	34.3	10.5	30.4	8.7	20.4	9.1
	3.	.013	31.6	7.2	30.2	9.0	22.1	7.2
	5.	.007	31.4	9.0	25.2	8.4	19.2	7.0
B.	1.	.044	25.2	6.7	25.2	7.5	24.8	5.9
	2.	.016	21.0	6.4	20.7	5.4	20.3	5.2
C.	2.	.016	29.4	8.5	26.5	7.1	21.7	5.1
H.	7.	.010	19.2	5.5	17.3	5.1	16.4	4.9

In obtaining the results in this table all unsuccessful trials were discarded. By an unsuccessful trial is meant an exposure in which no single word was read correctly, though certain characteristics of the words may have been observed and described correctly. This plan was adopted as the most conservative, though it doubtless gives a considerable advantage to the miscellaneous phrase and the miscellaneous word arrangements, since in these latter arrangements are found by far the greatest number of unsuccessful trials, the most of all appearing in the miscellaneous words. But each unsuccessful trial doubtless made possible a larger perception in the succeeding attempt and a consequent lessening of the total number of successful trials needed for the reading of a given group of words. Notwithstanding this handicap which we place upon the results of our method of calculation, the power-

[1] Explanation of abbreviations and terms: Subj. = Subject. Sel. = Selection of reading matter. Rate = Time of exposure in seconds. M. = Average amount in millimeters read per exposure. M. V. = The mean variation from the average of amounts read per exposure.

ful influence of context is in evidence at almost every point; there being only three slight exceptions in favor of the phrase arrangement over that of the paragraph in the records of subjects A. and B. Had the unsuccessful exposures been included in the calculations, the figures would of course show a still greater amount of the influence of context upon the amount read per exposure.

A more direct measure of the influence of context may be obtained by comparing the results of Table XVI in terms of per cents, using the amount read per exposure in the paragraph arrangement in each case as a standard, or one hundred per cent, with which to compare the amounts read per exposure in the same material arranged in the other two forms. Table XVII gives such a comparison.

TABLE XVII

Comparison in per cents of the amounts read correctly per exposure in the different arrangements of the same material, using the amounts read per exposure in the paragraph arrangement as a standard or 100 per cent.

Subject.	Sel.	Paragraph.	Phrases.	Words.
A.	1.	100.0	95.9	78.6
	2.	"	103.8	86.0
	3.	"	102.0	92.6
	4.	"	92.8	70.7
	5.	"	93.8	81.1
	6.	"	97.5	88.7
M.	1.	100.0	94.6	71.9
	2.	"	87.4	76.8
	3.	"	82.9	72.5
	4.	"	90.1	88.7
	5.	"	72.5	64.4
W.	1.	100.0	88.6	59.4
	3.	"	95.5	69.9
	5.	"	80.2	61.1
B.	1.	100.0	100.0	98.0
	2.	"	98.5	97.6
C.	2.	100.0	90.1	73.8
H.	7.	100.0	90.1	85.4
Mean		100.0	92.0	79.0

This table shows that in the phrase arrangement subjects read on an average 92 per cent as much per exposure as in the paragraph ar-

rangement, while in the miscellaneous word arrangement they read only 79 per cent as much. The influence of context is least marked in the case of B. and the most in the case of W. The variations due to the difference in the selections are quite large in the case of A., M. and W. but very little variation in the amounts read resulted from the variation of the length of exposure.

Another point of view, from which this table should be considered, is that it describes a definite portion of the total reading field. As previously mentioned, the figures represent the total amounts read correctly. But within this area are included two distinctions, *i. e.*, what was read *distinctly* and what was read *indistinctly*. The portion read indistinctly is given in Table XVIII and includes all distinctions which subjects classified as "doubtful," in whatever degree, ranging from mere guessing to mere lack of certainty. In this table are given under the heading "%," the per cents of all the exposures in which such doubtful distinctions appear. Otherwise the figures are arranged in the same order as those of Table XVI.

TABLE XVIII

The per cent of the total number of exposures in which words were read as "doubtful" and the average length in millimeters of such doubtful portions.

			Paragraph.			Phrases.			Words.		
Subject.	Sel.	Rate.	%	M.	M.V.	%	M.	M.V.	%	M.	M.V.
A.	1.	.044	7.	15.7	8.2	25.	21.0	7.3	15.	15.0	5.9
	2.	.016	12.	16.5	8.1	12.	16.6	4.9	13.	14.0	2.7
	3.	.013	21	14.3	6.1	18.	13.2	3.8	16.	14.6	2.0
	4.	.010	10.	13.0	2.0	28.	17.4	4.7	11.	10.9	2.3
	5.	.007	11.	14.5	4.5	8.	13.8	3.4	6.	12.8	5.1
M.	1.	.044	3.	18.0	8.0	5.	8.3	3.0	3.	7.6	2.6
	2.	.016	2.	10.0	5.0	3.	9.0	4.0	4.	10.5	6.1
	3.	.013	6.	10.0	2.5	3.	8.0	3.3	1.	7.0	0.0
	4.	.010	8.	12.2	7.1	6.	10.4	2.8	0.	0.0	0.0
	5.	.007	6.	12.4	3.2	3.	6.0	2.0	2.	6.0	2.0
W.	1.	.044	0.	0.0	0.0	6.	23.3	5.6	2.	10.0	3.0
	3.	.016	6.	19.0	12.0	4.	10.0	0.0	4.	9.6	3.3
	5.	.007	12.	14.6	5.0	7.	10.3	3.2	8.	12.0	6.0
B.	1.	.044	10.	11.0	8.9	9.	11.7	6.0	11.	16.8	4.7
	2.	.016	10.	12.0	4.1	12.	8.7	4.3	11.	10.0	4.0
C.	2.	.016	40.	11.4	4.8	24.	10.0	4.4	13.	12.7	4.7
H.	7.	.010	4.	7.6	3.3	3.	13.0	6.0	5.	13.4	4.0

This table shows to what extent successful guessing entered into the results. There does not appear to be any general tendency to guess in any one form of material more than another, though in the case of subject C. we have an apparent exception. In this case there is a regular curve of frequency corresponding to the amount of context, the number of successful guesses diminishing with the context. Nor is there any marked tendency to decrease either the size or the number of guesses as we pass from the longer to the shorter exposures. Concerning the variations, no definite uniformities are to be noted, doubtless indicating that the number of cases is too small to obtain a curve that would be entirely characteristic for any one individual.

Besides these distinctions which subjects were able to make within the portion of the field read correctly, there were a number of other more or less clear cut distinctions in the margin of the visual field beyond the limits of correct reading. In the present experiment where the method of successive exposure was used, these marginal distinctions occurred almost entirely within the right-hand portion of the field. The following five distinctions, or partial readings, were frequently noted: (1) Partial substitutions. By a partial substitution is meant any reading in which one or more letters were found in common between the word actually present and the one which was substituted for it. (2) Total substitutions. By a total substitution is meant a case where there was no letter in common, the only point of identity being the general appearance of the word present and the one substituted for it. (3) Correct forms of words. In this case the subject could not make a judgment as to what the word was, but was able to describe its general appearance, perhaps giving the number of letters and a general description of the letters, such as their shape, size, and position within the word. (4) Incorrect form. Here the subject saw clearly the word impression as a whole but failed to describe correctly the form or size of the word, the number of letters, etc. (5) No form. In many cases subjects were certain of the presence of one or more words in the margin, of whose form they could report nothing whatever. In such cases they were absolutely certain of the numerical aspect of the words present in the margin, though they could give no other quantitative characteristic, and nothing whatever of the specific qualitative character.

In some of these marginal distinctions there was evidently an element of illusion in the judgment, as for example, in the substitutions and the incorrect form, but in all cases there was as a rule very little lack of certainty.

The number of these marginal distinctions appearing simultaneously differs widely with different individuals and with different conditions.

Table XIX shows the relative frequency of the marginal distinctions reported by the various subjects.

TABLE XIX

The relative frequency of marginal distinctions reported by six subjects.

Subjects.	A.	M.	W.	B.	C.	H.	Mean.
No margin.	2.	6.	9.	1.	7.	11.	6.
One margin.	4.	10.	11.	3.	5.	10.	7.
Two margins	1.	1.	1.	1.	1.	1.	1.

The table as it stands is not entirely complete, for in a few instances subjects were able to detect three, sometimes even four, marginal distinctions simultaneously present. It is probable also that the figures opposite the distinction "no margin" are considerably less than they should be, because as the experiments became very familiar, subjects sometimes grew more or less lax in reporting cases of this kind. A point to be remembered is that none of the figures of this table represent the facts as they really exist, but only as the observer was able by careful observation to make them out. It is highly probable, therefore, that all the vaguer forms of marginal impression were present at each exposure, though their conscious discrimination, as the table shows, was comparatively infrequent.

It need hardly be remarked, furthermore, that these marginal distinctions are to be regarded as typical stages in the development of the perception of a word, cross sections, so to speak, taken at different levels in the development of the total perceptual process. This phase of the results will be considered further at a later point in our study of the marginal field and for the present we shall turn to a consideration of the data of the five marginal distinctions defined above.

In Table XX we present the data for the partial substitutions. Opposite each subject's name is found the frequency of such distinctions in per cents, their average size in millimeters, and the mean variations.

These per cents show a decided increase of frequency of the substitutions as we pass from the more perfect to the less perfect contexts. The frequency increases also with the decrease of the time of exposure, particularly in the more contextual arrangements. With reference to to the size of these misreadings, we find little uniformity in the variations though there is a slight tendency to decrease with a decrease of the exposure time. The variations in the size of the substitutions are themselves somewhat variable, showing that, in certain instances at least, the number of cases should be increased to produce a true ex-

pression of these relations. The question of partial substitutions will come up for further consideration when we take up a study of the detailed processes of word recognition.

TABLE XX

Frequency and size of partial substitutions, *i.e.*, of words, a part of whose letters and attributes were seen correctly.

			Paragraphs.			Phrases.			Words.		
Subj.	Sel.	Rate.	%	M.	M.V.		M.	M.V.	%	M.	M.V.
A.	1.	.044	3.	30.5	5.5	3.	29.5	13.5	15.	19.7	10.3
	2.	.016	16.	18.9	4.2	9.	18.0	8.4	22.	14.9	5.0
	3.	.013	19.	18.8	4.0	12.	14.2	3.1	24.	14.5	3.6
	4.	.010	7.	12.5	.5	21.	14.6	4.2	31.	15.2	5.0
	5.	.007	10.	16.4	2.1	17.	13.8	3.4	18.	18.0	7.0
M.	1.	.044	16.	15.8	7.7	23.	16.2	4.8	47.	21.3	6.6
	2.	.016	20.	12.2	4.0	27.	17.4	6.4	33.	15.9	6.9
	3.	.013	17.	14.9	4.1	45.	14.6	2.9	43.	13.7	4.9
	4.	.010	25.	16.6	5.3	37.	12.9	4.9	33.	14.0	5.6
	5.	.007	28.	16.6	6.0	46.	12.7	4.3	39.	14.5	5.5
W.	1.	.044	18.	15.0	6.4	34.	18.0	4.8	48.	18.9	7.7
	3.	.013	34.	11.4	2.2	43.	16.7	6.9	49.	19.8	11.0
	5.	.007	26.	13.5	5.8	41.	14.2	5.2	43.	16.0	6.7
B.	1.	.044	22.	15.7	6.0	30.	14.5	6.7	32.	14.0	5.8
	2.	.016	33.	12.1	4.0	29.	17.7	7.0	34.	13.9	3.8
C.	2.	.016	17.	14.1	5.1	20.	12.0	2.2	27.	16.5	6.5
H.	7.	.010	20.	10.7	3.2	26.	13.1	3.6	38.	12.4	2.6

The next distinction in degree of marginality is that which is defined above under the head of "total substitutions." I shall not take the space to tabulate the data for this distinction, as the number of cases is too small to show any characteristic changes with variations in the conditions of the experiment. The number of cases, however, is ample to prove the genuineness of the phenomenon and to show that it occurs in the reading of all subjects and in all forms of the material used. As previously pointed out these cases were peculiar in the fact that they are more illusory in character than any of the other marginal distinctions. There is a sense, however, in which the term "total substitution" is not a fitting designation for this class of phenomena for in almost every case there is traceable some more or less close re-

semblance in the general appearance between the word reported and the one for which it was mistaken, though this resemblance did not consist in such cases of any literal identity. In these instances the general appearance of the words proved to be the principal perceptual cue and was sufficiently strong to produce a feeling of certainty that the reading was done correctly. It would seem not unlikely therefore, that this aspect of the words is quite generally employed as the principal cue in the recognition of familiar words, more particularly when they occur in familiar contexts, and that the cases represented in this class are the occasional errors which would naturally occur when one relies to any large extent upon this factor.

TABLE XXI

The size in millimeters and the frequency in per cents of the marginal distinction designated "correct form."

			Paragraphs.			Phrases.			Words.		
Subj.	Sel.	Rate.	%	M.	M.V.	%	M.	M.V.	%	M.	M.V.
A.	1.	.044	50.	17.9	8.1	39.	25.2	10.9	22.	17.3	6.5
	2.	.016	37.	19.2	7.8	42.	19.1	6.1	31.	17.8	6.4
	3.	.013	42.	24.7	7.3	42.	23.1	7.3	36.	22.0	4.8
	4.	.010	46.	16.0	4.1	24.	14.3	4.3	28.	17.3	4.5
	5.	.007	38.	17.3	4.3	33.	16.7	4.9	40.	15.6	5.5
M.	1.	.044	12.	20.7	10.1	30.	15.2	7.7	18.	17.4	8.8
	2.	.016	11.	18.6	3.0	14.	15.0	6.7	12.	19.2	7.6
	3.	.013	3.	14.2	2.5	8.	17.2	5.6	6.	22.2	8.8
	4.	.010	14.	17.9	3.3	9.	18.9	6.4	6.	16.4	4.4
	5.	.007	6.	15.2	6.8	10.	15.9	5.6	9.	11.0	2.3
W.	1.	.044	10.	16.8	6.1	10.	13.8	12.0	4.	20.5	7.0
	3.	.013	18.	16.5	5.5	17.	19.4	6.6	8.	17.9	3.5
	5.	.007	9.	11.5	1.6	7.	16.0	7.3	11.	14.9	6.5
B.	1.	.044	52.	17.8	8.0	39.	19.0	7.5	31.	18.5	7.1
	2.	.016	27.	13.0	4.0	41.	15.0	5.3	22.	15.6	6.2
C.	2.	.016	2.	20.0	0.0	6.	10.0	0.0	6.	13.2	7.7
H.	7.	.010	10.	12.3	5.2	9.	13.2	2.2	10.	11.7	4.0

The next division of the marginal field is what has been designated above as "correct form." Under this heading, it will be remembered, were included all cases of correct or approximately correct description of the general appearance of words without any judgment as to

their literal constituents. For example, if a subject described the general size and shape of a word, or the number of letters with their size and position within the word, the observation was scored under this head. In such cases subjects were urged to guess, but while they were quite certain as to the general form of the word, they were unable to guess with any degree of certainty as to what the word was. Table XXI gives the frequency in per cents of this distinction, the average size in millimeters, and the variations.

Perhaps the most striking thing about this table is the comparatively great frequency with which this marginal distinction appears as is shown by the percentage columns. This is important as evidence of the value of the total word form as a cue to word recognition and so far verifies the observations made above. With most subjects the frequency tends slightly to decrease both with the decrease of context and with a decrease in the time of exposure. The same observation holds also for the absolute amounts read per exposure and for the vari-

TABLE XXII

The size in millimeters and the frequency in per cents of the marginal distinction designated "incorrect form."

			Paragraphs.			Phrases.			Words.		
Subj.	Sel.	Rate.	%	M.	M.V.	%	M.	M.V.	%	M.	M.V.
A.	1.	.044	21.	23.5	6.2	17.	26.0	6.1	20.	27.9	7.5
	2.	.016	19.	21.8	7.4	22.	23.3	7.6	16.	22.0	7.4
	3.	.013	7.	19.5	7.5	9.	19.2	9.6	11.	23.5	9.2
	4.	.010	10.	17.4	5.8	7.	13.3	4.2	5.	20.0	3.5
	5.	.007	4.	8.0	1.3	4.	16.5	7.5	4.	11.6	2.8
M.	1.	.044	10.	23.4	8.3	13.	17.3	7.0	9.	24.0	5.0
	2.	.016	0.	0.0	0.0	9.	11.9	3.3	3.	8.8	4.0
	3.	.013	0.	0.0	0.0	1.	7.0	0.0	1.	12.0	0.0
	4.	.010	1.	10.0	0.0	0.	0.0	0.0	1.	17.0	0.0
	5.	.007	1.	12.0	0.0	1.	9.0	1.0	3.	10.0	0.0
W.	1.	.044	3.	13.0	9.0	2.	25.0	0.0	3.	26.6	6.0
	3.	.013	6.	14.5	2.5	2.	38.0	0.0	4.	23.3	15.0
	5.	.007	1.	15.0	0.0	5.	17.0	4.6	3.	28.0	8.6
B.	1.	.044	13.	23.3	5.2	16.	19.8	7.9	5.	17.5	9.0
	2.	.016	4.	11.0	7.3	1.	15.0	0.0	5.	15.5	.5
C.	2.	.016	2.	15.0	0.0	2.	12.0	0.0	1.	22.0	0.0
H.	7.	.010	7.	10.7	2.2	1.	10.0	0.0	2.	7.0	3.3

ations. Table XXII sets forth the results for the marginal distinction designated as "incorrect form."

The frequency of this distinction is relatively small and grows less, in fact almost vanishes, with practise. This fact further reinforces the observation that the form of the word is an important factor in the recognition process. The figures of this table are valuable, therefore, chiefly as a negative argument and represent the frequency with which one may expect such errors to occur. Owing to the fewness of the cases no very reliable changes in the results are noticeable with changes in the conditions of the experiment, barring the one exception already mentioned.

The last marginal distinction to be described is the one which I have designated as "no form." The results of this study are set forth in Table XXIII.

TABLE XXIII

The frequency in per cents with which the presence of words was noted without any discrimination of their specific qualitative or quantitative characteristics. The average size and variability of such distinctions.

			Paragraphs.			Phrases.			Words.		
Subj.	Sel.	Rate.	%	M.	M.V.	%	M.	M.V.	%	M.	M.V.
A.	1.	.044	17.	24.4	8.6	25.	23.4	10.3	20.	22.0	10.8
	2.	.016	23.	26.9	14.7	22.	17.2	7.6	33.	21.7	9.4
	3.	.013	23.	16.4	4.3	31.	26.0	8.2	31.	20.0	9.6
	4.	.010	14.	20.5	5.4	12.	32.0	6.8	22.	20.6	8.0
	5.	.007	1.	11.0	0.0	9.	11.7	5.4	6.	11.1	4.1
M.	1.	.044	17.	12.6	6.0	10.	12.2	9.8	7.	23.2	14.4
	2.	.016	19.	11.6	7.9	16.	11.7	5.4	10.	12.4	7.2
	3.	.013	20.	9.0	3.6	11.	11.4	4.7	16.	10.2	5.1
	4.	.010	22.	12.4	7.2	9.	12.4	4.4	20.	11.2	3.0
	5.	.007	1.	10.0	0.0	10.	9.4	2.6	12.	9.1	4.7
W.	1.	.044	5.	32.3	11.0	2.	4.0	0.0	1.	12.0	0.0
	3.	.013	15.	14.2	5.6	0.	0.0	0.0	10.	14.8	2.2
	5.	.007	4.	12.5	2.5	0.	0.0	0.0	3.	18.3	1.0
B.	1	.044	19.	14.4	4.9	18.	17.5	6.2	20.	16.3	8.7
	2.	.016	24.	10.0	4.8	18.	8.0	4.1	25.	11.9	4.5
C.	2.	.016	11.	10.4	5.6	6.	25.0	7.0	9.	23.5	9.1
H.	7.	.010	14.	11.1	4.7	7.	13.1	4.8	4.	10.8	2.0

As already pointed out, the frequency of this marginal distinction s perhaps not as fully represented as it should be, but it is nevertheless sufficiently full to indicate the genuineness of the fact. Although the impressions are the least clear and definite of all the marginal distinctions, and hence the least faithfully representative of the words, yet subjects judged with no greater difficulty nor with less certainty. From these facts the presumption is very strong that this aspect of words is the first to strike the attention of practised readers, particularly in dealing with familiar material.

The table shows no very significant changes in the frequency and size of the groups perceived with changes in the conditions of the experiment.

We will now pass to a study of the relation of the separate processes of word perception simultaneously present within the reading field. Table XXIV shows to what extent the size of the area of correct reading varies with a variation in the number of marginal distinctions. The table was derived by choosing at random about half of the total number of experiments and tabulating them under the following headings: (1) No marginal distinctions, (2) one marginal distinction, (3) two marginal distinctions, etc., without regard to the nature of those distinctions. The table contains the average size of the area of correct reading for each individual under each of the above conditions.

TABLE XXIV

Variations in the area of correct reading concomitant with variations in the number of marginal distinctions simultaneously present. Figures represent millimeters.

	No marginal distinction.		One marginal distinction.		Two marginal distinctions.	
Subject.	M.	M.V.	M.	M.V.	M.	M.V.
A.	28.5	7.0	25.9	5.8	19.0	6.6
M.	22.9	8.0	16.1	7.3	17.1	8.7
W.	31.8	8.8	22.9	6.8	21.8	10.2
B.	24.5	8.6	19.0	5.6	17.6	5.4
C.	26.0	8.1	18.6	6.3	14.4	4.2
H.	18.5	5.7	13.1	4.6	13.0	6.6

The table shows almost uniformly that the size of the area of correct reading varies inversely as the number of marginal distinctions. It seems obvious, therefore, that the "forward glance" during a given exposure has the effect of lessening the amount which can be read correctly during that exposure.

Applying this result to the process of ordinary reading and assuming what seems to be highly probable, *viz.*, that within the normal reading pause we have the same divided state of attention as in the single

exposure, the presence of distinct marginal impressions undoubtedly has a narrowing effect upon the focal area. In order to account for the selection of this method of perception in normal reading we must suppose that this narrowing effect is more than compensated for by the increased quickness of perception of the impressions within that area, and hence the more rapid succession of reading pauses, made possible by the preparatory and orienting effect of the right-hand marginal impressions of one reading pause upon the focal impressions of the pause immediately following.

Experiment 7. Tachistoscopic Reading by Successive Exposures by Naïve Subjects.

A possible argument against the above generalizations may be made on the ground that the subjects in the previous experiment were much accustomed to introspection and may have thus created artificial distinctions, such as would not appear to the inexperienced observer. In order to test this point, experiments were made with a number of naïve subjects under the same conditions. The subjects were advanced students in the university and in general intelligence would compare

TABLE XXV

Amounts read correctly per exposure by naïve subjects, and the frequency in per cents of the appearance of marginal distinctions. Figures represent millimeters. Time of exposure, .044 second.

	Amount read per exposure.		Frequency of one margin.	Frequency of two margins.
Subject.	M.	M.V.	%	%
W.	20.5	7.1	56.	3.
B.	19.4	6.5	44.	0.
L.	23.1	8.1	62.	2.
H.	36.0	9.3	32.	0.
Mc.D.	31.9	8.0	52.	3.
Y.	29.2	11.1	47.	9.
J.	25.5	8.3	16.	2.
B.	19.0	6.7	56.	0.
Jo.	14.3	4.7	36.	1.

favorably with the psychologists in the experiments already recorded. Each subject read at one sitting a paragraph of one hundred words by the method of successive exposures. They were instructed to complete the reading in the fewest possible exposures and after each exposure to describe all they saw, stating the degree of certainty in every case. Aside from these general instructions the operator was particularly careful to avoid giving any hint as to the different distinctions which might be seen. Table XXV presents for nine individuals the average amount in millimeters read correctly per exposure, also the number of times in per cents when marginal distinctions were reported.

These figures show that naïve subjects reported marginal distinctions on an average about fifty per cent of the time. The number of distinctions simultaneously present and their distribution over the various gradations are approximately the same as in the experiment with the trained psychologists (see Table XIX). Apart from the question of marginal distinctions this table has some interest from the standpoint of individual differences. Although more individuals would be needed for a thorough study of this question, from the results we should expect to find marked differences in the average amounts read per exposure as well as in the relative sizes of the variations.

II. THE DEVELOPMENT OF WORD PERCEPTION

1. Synthetic Phase

It has already been pointed out that each of the marginal phenomena above described represents a typical stage in the development of the perception of a single word. This view was corroborated by the results of the unsuccessful exposures (cases of incomplete recognition excluded from my tables) in which only certain general aspects of words were noted. As the cases were comparatively few and the results not new or different from the marginal distinctions already described, I have not taken the space for tabulating the data. Further corroborative evidence of this view was also found in the introspective reports. Under the most favorable circumstances subjects were able to describe one or other of these stages in the development of the perceptual process, the best conditions obtaining when the intensity of the stimulus approximated most nearly to the threshold for word recognition.

It is not to be inferred, however, that the perceptual distinctions described in the above tables represent all the possible stages in the process of word recognition. On the contrary, these distinctions are adequate only in the recognition of familiar words, while in dealing with strange or difficult words or in the case of some unfavorable condition a further development of the perceptual process is necessary

before the final stage of word recognition is reached. This further development in contrast with the earlier phase represented by the tables is primarily analytic in character and consists of a more or less detailed analysis of the words into their literal components. A study of this analytic phase will be the next problem.

2. *Analytic Phase*

The best opportunity to obtain objective data for this study is found in those cases of partial word perception which lie nearest the threshold for word recognition. These have been designated partial substitutions, and in them this phase of analysis is best represented. While it is evident that in many instances the analysis is carried far beyond the point required in normal reading because of the unusual conditions, it is not in the least probable that the laws which obtain in tachistoscopic reading are qualitatively different from those which prevail in ordinary word recognition.

From this study of partial substitution it is hoped to obtain exact information concerning the extent to which word recognition in these instances depends upon recognition of the literal components of the word, also the comparative value of different letters as cues for such recognition, and the variation of these values with the different positions within the word.

The study was carried out by making for each subject tables of frequency (1) for all the letters contained in the words for which substitutions were made, (2) for all the letters in the substitute words which appear also in the words for which they were substituted. From these tables, then, the frequency of recognition for most of the letters of the alphabet was calculated in per cents. When distributed in this manner, the number of cases for different letters varied considerably, and in only a comparatively few instances was the number of cases as great as could be desired. Table XXVI presents the results for those individuals from whom the largest number of cases was obtained. The number of cases for a given letter appears alongside the per cent as a check on the latter.

Several considerations must be kept in mind in the interpretation of this table. In the first place, it is certain that these results are not due to the operation of one factor merely but to the cooperation of a number of factors. For example, we are not justified in assuming that these figures represent in any exact sense the relative perceptibility of the various letters, although this factor of perceptibility is without doubt partly responsible for the disparity of the per cents. So also for various other possible factors, no one of which can be assumed *a priori* to be wholly or even chiefly responsible for the result in any given instance. Among the most important of these possible

TABLE XXVI

The frequency in per cents with which various letters are found in common between words and their substitutes, in the cases of partial substitutions.

	Subject A.		Subject M.		Subject W.		Subject B.	
Letters.	Cases.	%	Cases.	%	Cases.	%	Cases.	%
A.	153.	47.	236.	45.	106.	47.	67.	41.
B.	53.	30.	48.	35.	25.	32.	10.	50.
C.	72.	50.	72.	54.	20.	60.	23.	39.
D.	92.	45.	145.	34.	71.	38.	31.	51.
E.	229.	51.	432.	63.	197.	54.	111.	51.
F.	49.	49.	105.	54.	21.	38.	34.	67.
H.	80.	63.	123.	50.	48.	54.	31.	35.
I.	113.	57.	230.	60.	83.	43.	69.	45.
L.	98.	46.	121.	55.	48.	50.	43.	63.
N.	121.	57.	235.	54.	82.	49.	73.	52.
O.	161.	65.	161.	56.	66.	56.	59.	52.
R.	169.	47.	237.	60.	101.	46.	60.	33.
S.	155.	45.	234.	34.	123.	47.	78.	43.
T.	128.	55.	194.	59.	91.	75.	62.	69.
Y.	47.	49.	49.	61.	15.	40.	27.	66.
M.		50.4		51.6		48.6		50.4
M.V.		6.0		9.4		7.9		9.0

factors which suggest themselves are the following: (1) Frequency of occurrence of the letter. It is a notable fact that in every case where the frequency of a letter is relatively great the per cent of recognitions is at least equal to the average and in some cases above it. It is natural to suppose, therefore, that there is some relation between these

facts. (2) The relative perceptibility of letters. It is a well established fact since the work of Professor Cattell[1] that the different letters of the alphabet vary widely in their perceptibility. The following is the order of perceptibility found by Professor Cattell, beginning with the least difficult: w z m d h k n x a y o g l q i s c t r p b v f u j e.

Table XXVII compares these results of Cattell with those of four of my subjects. The letters appear in the column under each subject's initial in the order of the size of their per cent of recognitions, beginning at the top of the column with those having the highest percentages. The braces connecting certain letters indicate that these letters had the same per cents.

TABLE XXVII

Comparison of the relative perceptibility of letters with the per cent of recognitions incident to the recognition of words.

Relative perceptibility.		Per cent of recognitions.			
		A.	M.	W.	B.
1.	d	o	e	t	t
2.	h	h	y	c	f
3.	n	n	r	o	y
4.	a	i	i	h	l
5.	y	t	t	e	o
6.	o	e	o	l	n
7.	l	c	l	n	e
8.	i	y	n	s	d
9.	s	f	f	a	b
10.	c	r	c	r	i
11.	t	a	h	i	s
12.	r	l	a	y	a
13.	b	s	b	f	c
14.	f	d	s	d	h
15.	e	b	d	b	r

This table shows little or no correspondence between the per cent of letter recognitions and the relative perceptibility. If therefore the relative perceptibility of letters is a factor in determining the per cents of their recognition incidental to the process of word recognition, its influence is almost wholly obscured by the combined influence of other factors. (3) Accidental conditions, such as favorable focus of

[1] *Phil. Studien*, 3, 93*ff*.

the attention, etc. It is highly probable that the factor of chance played at least a small part in producing my results, since the exposure time for word recognition could not be reduced to a point below that within which recognition of any of the letters would still be possible. As a consequence, many letter recognitions must have occurred in spite of the lack of prominence of the letters, and this fact doubtless contributed a certain share in swelling the per cents unduly for certain letters in the table. The method of calculation also possibly contributed more or less to this same end. For example, it is probably not true that all the letters which are found in common between the word and its substitute were actually perceived. On the contrary, it is quite likely that at least a certain small percentage of these letters chanced to make up a part of the word substituted and that they were not actually perceived in the original word. It is evident, however, that both these sources of error would tend gradually to correct themselves as the number of the cases increased though perhaps never quite completely, since chance would always tend to favor those letters which occur most frequently. (4) The kind of print. It seems quite probable that the relative perceptibility of different letters must vary more or less with the different styles of type. One might expect this to be especially true for certain letters if he were to compare typewriting with ordinary print. Owing to mechanical necessity, all letters in typewriting are given the same space regardless of their width. This arrangement gives advantage for purposes of perception to the narrower letters, such as "l" or "i", while the broader letters, such as "m" or "w" are actually compressed laterally and their normal proportions distorted. (5) Position of the letters within the word. It is evident from the results of Huey,[1] Pillsbury,[2] and others that the position of the letter within the word modifies its chances of being perceived. Pillsbury, for example, tested the comparative value of the different positions within the word by means of mutilations and omissions of letters, his conclusions being based on the comparative frequency with which subjects overlooked these changes. This method, however, has one defect which the author himself recognizes, namely, the difficulty of keeping the subject in total ignorance of the method and purpose of the experiment. (6) Association. It is probable that certain combinations of letters have an optical completeness and prominence, due rather to the group as such than to the objective prominence of any of the letters composing the group. If this were true, there would be a tendency for those letters frequently appearing in such groups to acquire a sort of fictitious prominence which would to this extent swell their per cents beyond the true measure of their relative

[1] "The Psychology and Physiology of Reading," *Am. J. Psych.*, 10, 11, 12.

[2] "The Reading of Words," *Am. J. Psych.*, 8.

perceptibility. (7) Special interest for particular letters. The introspective reports show that almost every subject had certain favorite letters which he mentioned more frequently than others.

A typical case is presented in the following table which compares for subject A. the percentages of special mentions of various letters with the percentages of actual recognitions of these same letters, as evidenced by their appearance in substituted words.

TABLE XXVIII

The frequency in per cents of the introspective reports of prominent letters compared with the frequency of their actual recognitions. Subject A.

	Number of letters.	% of reported letters.	% of substitutions.
A.	189.	9.5	47.
B.	36.	8.3	30.
C.	39.	23.	50.
D.	85.	18.8	45.
E.	290.	4.7	51.
F.	56.	23.3	49.
G.	43.	30.2	38.
H.	147.	8.1	63.
I.	141.	11.3	57.
L.	82.	26.8	46.
M	39.	10.2	59.
N.	152.	8.5	57.
O.	145.	7.5	65.
P.	39.	46.1	61.
R.	137.	10.2	47.
S.	162.	11.1	45.
T.	198.	9.	55.
U.	55.	12.7	30.
Y.	33.	18.1	49.

This table shows that the favorite letters were usually, though not always, among the more objectively prominent letters. But the unreliability of the introspective reports as indices of the values of different letters as cues for word perception is indicated by the fact that in only one case out of seven favorite letters is the percentage of actual recognitions high, few of them being up to the average.

Doubtless there are other factors still which cooperate in producing the results in Table XXVI, but I have enumerated a sufficient number perhaps to warrant the belief already stated, that these figures are not due to any one but rather to a number of causes.

In general it may be observed that in the partial substitutions about fifty per cent of the letters were recognized. On this basis it would presumably require a still greater percentage of letter recognitions for correct perception of these same words, provided the condi-

tions remained the same. On the other hand, in case the conditions were most favorable and the words not strange or unfamiliar, it is reasonably certain that no such large percentage of literal recognitions would be required.

The relative frequency of recognition of the different letters of the alphabet differs rather widely and the curve of literal recognition in context does not correspond to that of the same letters when taken in isolation. As pointed out above, this lack of correspondence is explainable on the ground of the complexity of the conditions involved in the recognition of letters incident to the recognition of words.

It may be noted, finally, that my results do not favor the so-called dominant letter theory of Zeitler,[1] Mesmer,[2] and others, which maintains that the most objectively prominent letters play the principal rôle in the process of word recognition. While there is probably no doubt about the presence of this factor its influence is generally very much obscured and often apparently obliterated by the combined influence of other factors.

Among the different factors enumerated above as complicating the results of Table XXVI, the factor of the position of letters within the word offers the best opportuntity for further quantitative study. In Table XXIX the per cent of letter recognitions in the partial substitutions are arranged for five different positions within the word. The calculations are made for six subjects and the method is the same as that employed in deriving Table XXVI.

TABLE XXIX

Frequency in per cents of letter recognitions for five different positions within the word.

	First.		Seco nd.		Middle.		Pre-final.		Final.			
Subject.	Cases.	%	Cases.	%	Cases.	%	Cases.	%	Cases.	%	M.	M.V.
A.	374.	64.1	335.	59.2	640.	52.1	239.	39.1	391.	41.2	51.3	8.7
M.	300.	58.3	262.	62.2	519.	50.6	238.	44.9	289.	35.6	50.3	8.3
W.	233.	65.2	220.	61.8	440.	55.9	184.	50.5	233.	59.6	53.8	9.5
B.	143.	69.2	135.	61.4	301.	33.8	123.	31.7	133.	40.6	51.4	18.9
C.	61.	47.5	60.	60.0	92.	43.4	44.	45.4	61.	37.7	46.8	7.4
H.	85.	58.8	77.	70.1	112.	58.9	70.	44.2	86.	65.1	59.6	7.1

[1] Tachistoskopische Versuche über das Lesen, *Phil. Studien*, **16**, 380–463.

[2] *Archiv für die Gesamte Psychologie*, **2**.

This table shows that for all individuals literal reading is decidedly more likely to occur in the first than in the latter portion of the word. There is, however, only one complete agreement among the different individuals in the order of preference for the different positions within the word, *viz.*, between the results of subjects W. and B. Table XXX compares directly the order of preference for the five positions within the word.

TABLE XXX

Five positions within the word ranked in the order of frequency of literal recognition for six subjects.

Rank.	Subject A.	Subject M.	Subject W.	Subject B.	Subject C.	Subject H.	Mean
1.	1st	2nd	1st	1st	2nd	2nd	2nd
2.	2nd	1st	2nd	2nd	1st	5th	1st
3.	3rd	3rd	5th	5th	4th	3rd	3rd
4.	5th	4th	3rd	3rd	3rd	1st	5th
5.	4th	5th	4th	4th	5th	4th	4th

If we divide the word into three portions so that the first portion is composed of the first and second letters of the word, the third of the pre-final and final letters, and the middle of the remaining letters, we get the results set forth in Table XXXI.

TABLE XXXI

Frequency in per cents of letter recognitions for three different positions within the word.

	First.		Middle.		Last.	
Subject.	Cases.	%	Cases.	%	Cases.	%
A.	709.	61.8	640.	52.1	630.	41.2
M.	562.	60.1	519.	50.6	527.	39.8
W.	453.	63.5	440.	55.9	417.	55.6
B.	278.	65.3	301.	33.8	256.	36.1
C.	121.	53.2	92.	43.4	105.	41.5
H.	162.	64.4	112.	58.9	156.	54.6

With one slight exception in the case of subject B. this table shows that there is a regular decrease in the amount of literal recognition as we progress from the first to the last portion of the word. This confirms the results of Pillsbury[1] who found that subjects were less liable to overlook mutilated or omitted letters in the first than in the latter portions of the word.

It is perhaps worth noting that in word recognition we have apparently the same law repeating itself on a modified scale, which was found to hold for the total reading field. It will be remembered that in the total reading field the region of clearest vision habitually occurred in the left-hand portion, and the distinctness of perception gradually decreased toward the right. This law, however, can be said to hold for word recognition only in a general way, for when we examine the results in detail we find several distinct varieties or types of word perception, some of which do not harmonize with this statement. All that can be said is that the most frequently occurring type of word recognition does agree with the above statement of the law. The following table contains examples of the different types of word perception considered from the standpoint of the position of the recognized letters within the word. The first column contains the words actually presented, and the second column contains the substitutions. The italicized letters are those found in common between the two sets of words.

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[1] *Op. Cit.*

TABLE XXXII

Examples of substitutions showing different types of word perception. Perceived letters are italicized.

First Letters

Word.	Substitution.	Word.	Substitution.
*be*d	*be*st	*gr*eat	*gr*ey
*so*on	*so*me	*th*at	*th*ere
*ma*ny	*im*age	*pl*ots	*pl*ace
*thi*ef	*thi*ther	*b*aby	*b*ird
*fr*eeze	*fr*esh	*Pa*ris	*pa*rt
*ca*ught	*cr*awling	*th*is	*th*ere

Middle Letters

Word.	Substitution.	Word.	Substitution.
d*ar*kne*ss*	ch*ar*ge*s*	b*and*it	h*and*
am*ong*	*on*e	bu*ild*	*ill*
wo*rld*'s	cou*ld*n't	h*o*m*e*	fr*om*
de*ad*	s*at*	l*ea*ky	b*e*t
p*an*	g*r*a*ss*	a*nd*	i*n*
b*eav*er	l*eav*es	flowers	Tom

Last Letters

Word.	Substitution.	Word.	Substitution.
ho*me*	ca*me*	lo*ve*	ha*ve*
b*y*	the*y*	ne*st*	mo*st*
he*ard*	bo*ard*	wate*r*	offe*r*
shaggy	grizzly	hold*ing*	bring*ing*
m*ere*	th*ere*	m*ain*	ch*ain*
fou*nd*	ha*nd*	p*et*	g*et*

First and Middle Letters

Word.	Substitution.	Word.	Substitution.
*hea*r	*hea*ps	*sa*t	wa*s*
*ho*nest	*ho*me	*hun*ter	*haun*t
*thi*ef	*thi*er	*Plo*ts	*Pla*to
*ste*al	*sta*nd	*ho*ney	*ho*me
*beav*er	*beca*use	giv*en*	grav*es*
*gr*eat	*gr*ey	*wa*tched	*whi*ch

First and Last Letters

Word.	Substitution.	Word.	Substitution.
houses	*homes*	*fell*	*fall*
hatched	*harassed*	*and*	*aid*
child	*could*	*but*	*bit*
booty	*beauty*	*after*	*afraid*
poor	*power*	*secure*	*scene*
wants	*worst*	*supply*	*simply*

Middle and Last Letters

Word.	Substitution.	Word.	Substitution.
p*ier*	ch*air*	ho*lding*	bui*lding*
b*ig*	h*igh*	boo*ty*	hone*y*
f*all*	tr*ail*	s*aw*	a*new*
confu*sion*	que*stion*	hea*ped*	dam*ped*
hea*vy*	ba*by*	n*ever*	*ever*
h*and*	l*and*	h*ave*	lea*ve*

First, Middle, and Last Letters

Word.	Substitution.	Word.	Substitution.
printed	*prolonged*	*era*	*are*
nest	*next*	*liberty*	*briefly*
there	*three*	*flowers*	*follows*
peasant	*present*	*sculptor*	*scrupulous*
centuries	*continuous*	*hordes*	*herds*
possessed	*oppressed*	*little*	*letters*

The comparative frequency of the different types is shown in Table XXXIII. The initials F., M., L., etc., in the first column represent the various positions within the word, *i. e.*, first, middle, last, etc. Those at the head of the columns stand for the different subjects.

TABLE XXXIII

The comparative frequency in per cents of the different types of word perception as determined by the positions, within the word, of the literal recognitions.

Type.	A.	M.	W.	B.
F.	24.	24.	15.	25
F. and M.	14.1	28.	9.	15.
F. and L.	22.2	6.	14.	16.
F., M., and L.	19.7	15.	26.	17.
M.	3.	14.	10.	11.
M. and L.	9.2	9.	6.	8.
L.	8.	4.	20.	8.

According to these results the curves presented in Tables XXIX and XXXI represent a mixture of species or types of word perception, the size of the per cents for the different positions within the word indicating the relative frequency of each type. While the table shows that certain types occur more frequently than others, yet the distribution of the percentages is sufficiently wide to indicate that all the types are real.

Another question of interest is the relative frequency of recognition of different letters in the different positions within the word. Although this is a rather large problem in itself and would require in most instances a much larger number of cases than we have at our disposal, I venture to submit samples of the results, chiefly on account of the method, which promises to be of value in the solution of this problem. Table XXXIV contains the per cents of recognitions for various letters in different positions within the word. The number of cases appears in connection with the per cents, and in no instance is the figure given for any position based on fewer than ten cases.

In studying these figures it should be kept in mind that for any particular letter there may be certain positions within the word where it rarely, if ever, occurs. This fact accounts for many of the vacant spaces in the table, but it still leaves a considerable number of cases to be explained on the ground of mental peculiarities of subjects, characteristic forms of letters, accidental circumstances, or various combinations of these and other factors. We may, however, be fairly justified in disregarding the factor of accident wherever the curves assume a marked degree of uniformity or of regularity. In such cases it seems quite probable that we have at least a rough measure of the two remaining factors for different letters in different positions within the word, though it may not be possible in any instance to analyze and completely evaluate each of these factors from the data at hand. This view is rendered more probable by the fact that the percentages vary only to a slight degree with the number of cases, indicating that we are likely to obtain a characteristic curve for any letter in the different positions within the word with comparatively few cases.

I shall not take the space to comment upon these figures further than to point out that here again my results fail to lend any material support to the dominant letter theory, referred to above, and to suggest what appear to be more probable dominant influences in determining the higher percentages in the table. The first of such influences which may be suggested is the comparatively great frequency with which certain letters occur in ordinary discourse, such, for example, as the letters a, e, n, r, s, etc. As noted above we find that in every case where the frequency of occurrence of a letter is relatively great the per cent of recognition is high, and this, regardless of the prominence

of the letter concerned. The other influence which appears to be a dominant one is the mental habit of associating letters with their customary positions within the words. Where such a habit exists it is evident that a minimal stimulation is all that is necessary in order to produce an adequate impression of any letter. But no such habit can be adequate to meet all situations in which a given letter may occur. Hence the frequent liability to error in spite of the habit. Certain letters and certain positions within the word are naturally more subject to such ambiguities than others and these are indicated in the table by their comparatively low percentages.

TABLE XXXIV

Percentage of recognitions for various letters in different positions within the word.

Subject.	First.		Second.		Middle.		Pre-final.		Final.	
	Cases.	%	Cases.	%	Cases.	%	Cases.	%	Cases.	%
					A.					
A.	29.	72.0	63.	60.3	52.	34.8	11.	45.4		
M.	15.	46.6	48.	52.0	69.	39.1	11.	63.6		
W.			34.	52.8	58.	55.1	11.	63.6		
B.	10.	60.0	25.	64.0	24.	16.0				
					C.					
A.	40.	72.5			28.	42.5				
M.	10.	80.0			11.	63.6				
W.	11.	72.7								
B.					11.	18.0				
					D.					
A.					15.	60.0			62.	38.7
M.	16.	56.2							51.	31.3
W.					17.	47.0			38.	50.0
B.									18.	38.8
					E.					
A.	10.	50.0	33.	48.4	68.	62.3	60.	50.0	53.	43.3
M.			50.	64.0	64.	57.8	58.	63.8	42.	57.1
W.			56.	69.6	45.	71.1	51.	62.7	48.	66.6
B.			25.	68.0	34.	35.2	28.	53.5	21.	38.0
					I.					
A.			35.	48.5	58.	60.3	17.	17.6		
M.	14.	57.0	33.	81.8	41.	43.9	10.	50.0		
W.			25.	64.0	48.	45.8				
B.			16.	68.7	39.	33.3				
					L.					
A.	16.	37.5			28.	57.1	43.	53.4		
M.	15.	100.0			22.	63.6	12.	33.3		
W.	14.	42.8					18.	50.0	10.	83.3
B.					14.	42.8				

		N.			
A.	13. 46.0		31. 70.9	39. 45.5	41. 36.5
M.		14. 71.4	27. 66.6	32. 56.2	37. 35.1
W.		13. 69.2	23. 47.8	23. 65.2	28. 60.7
B.		10. 80.0	18. 38.8	26. 50.0	11. 18.1
		O.			
A.	20. 90.0	63. 77.0	47. 51.0	19. 42.1	
M.		37. 62.1	26. 65.3	15 66.6	
W.		29. 48.2	13. 53.8	14. 42.8	
B.		24. 66.6	22. 45.4		
		P.			
A.	18. 100.0	10. 0.0	16. 37.5		
M.	25. 68.0		33. 51.5		
W.	35. 82.8		13. 61.5		
B.	14. 92.8				
		R.			
A.	15. 60.0	19. 89.4	99. 50.5	20. 25.0	10. 60.0
M.	13. 84.6	18. 72.2	63. 65.0	16. 50.0	16. 56.2
W.		11. 72.7	51. 74.5	12. 33.3	16. 50.0
B.			30. 20.0	13. 38.4	
		S.			
A.	33. 39.6		39. 61.5	26. 38.4	68. 27.9
M.	25. 56.0		27. 48.1	20. 15.0	54. 28.8
W.	23. 73.9		35. 68.5	16. 56.2	44. 43.1
B.	11. 54.5		17. 58.8		38. 28.9
		T.			
A.	29. 75.8	10. 60.0	49. 57.1		29. 41.3
M.	16. 75.0	12. 75.0	39. 71.7		25. 0.0
W.	18. 72.2	12 100.0	38. 78.9		23. 95.6
B.	16. 75.0		24. 50.0		14. 78.5

CONCLUSION

It remains now to say a few words by way of general summary and application of the results of this study.

In the first place it has been found that in every form of experiment in reading which has been undertaken, the influence of context as a condition of word recognition is strongly in evidence. It has also been found that for all subjects ranging from about the age of nine or ten up to maturity the constituent elements of context, *i. e.*, the phrase, the sentence, the paragraph, etc., have each a definite measurable value as an aid in the perception of words. The influence of these factors varies with different individuals, with maturity, with practise, and with different selections of reading matter, the latter varying directly with the perfection of context. The value of these facts as a warrant for the pedagogical practise of presenting reading lessons in the form of whole compositions is obvious.

In the study of the detailed processes of word perception, it is seen that within the area of relatively clear vision, certain portions only are selected, *viz.*, the focal area or the *area of distinct attention* and that of the right-hand marginal impressions, and these taken together constitute what I have chosen to call the *reading field.* Within this reading field there are going on simultaneously and side by side several relatively independent processes of word perception whose degree of development varies inversely as their degree of marginality. This development extends through the entire series of perceptual distinctions represented in the tables, from complete recognition on the left to a mere consciousness of "something there" on the right. Besides the distinction between margin and focus there are within the focal area itself further distinctions corresponding to the separate word impressions, and the order in which these impressions come to full recognition is normally the order in which the words appear upon the page in passing from left to right. In the majority of cases little further analysis is necessary, the general characteristics of the word being the principal cue by which it is recognized. But when some unfavorable condition arises or when the words are strange or difficult, additional distinctions within the word are required, in which case the parts of the word must be brought more or less clearly to consciousness according to the degree of the complexity or unfamiliarity. It is probable, however, that a certain amount of literal analysis always takes place in some of the words, even under the most favorable conditions, owing to the peculiar structure of the visual apparatus, to the chance direction of the attention, and to the prominence of certain letters due to their size, peculiar structure, or to

their more or less favorable position within the word. But as a rule, conscious resort to such analysis occurs only when the word presents some special difficulty and spontaneous recognition by means of the more general attributes of the word fails. The form of procedure may, therefore, be described as predominantly synthetic-analytic, the amount of analysis tending in general to decrease with growth in ability and with increasing familiarity with the material read. Something doubtless depends upon the peculiar mental habits of the individual, possibly also upon the methods employed in learning to read.

It has been possible to make an exact statement of the amount of this analysis only in the case of partial substitutions, which, of course, classify under the head of difficult or strange words, or what is equivalent to this, *viz.*, familiar words read under unfavorable conditions. In such cases it has been found in general that about fifty per cent. of the letters are recognized. More literal recognitions take place in the first part of the word, the frequency decreasing regularly from the first to the last. The frequency of such recognitions is not influenced to any very appreciable extent by the prominence of the letters, but rather more by the frequency of occurrence of the letters in the words, and by the mental habit of associating letters with their customary positions within the words. An important application of this analysis of the reading field is that the perceptual distinctions thus found may be taken as representing more or less approximately, the stages which actually occur in the process of word recognition. These stages are not easily demonstrable by the method of introspection and it is only as they appear as separate perceptual distinctions within the total reading field that it has been possible to obtain any definite quantitative statement of their real character.

As to the cause of the perceptual distinctions described in the tables the present state of our knowledge is not such as to admit of a satisfactory theory. But if we consider these results in the light of related studies of the problem of reading, a number of factors seem fairly well-defined. Among the most important of these are the following: (1) The lack of uniformity in retinal development. It is well known that the portion of the retina involved in a single perceptual group, which probably never exceeds a lateral diameter of more than two or three millimeters is, as a rule, never uniform in its development, its sensitivity tending gradually to decrease towards the periphery.[1]

As a result the intensity of retinal impressions would tend to vary in the same direction as would also the recognition of these impressions. But the exact extent to which this factor is responsible for the inequal-

[1] W. C. Ruediger. "The Area of Distinct Vision," *Archives of Psych.*, No. 5, 1907.

ity of perceptual distinctions is thrown in doubt by the fact that in the smaller perceptual groups where the factor of retinal disparity would presumably be reduced to a negligible quantity, we still find these perceptual distinctions to prevail. We are accordingly forced to look further for a satisfactory explanation. (2) A second probable cause is to be found, therefore, in the fading out of the impressions on the right-hand margin of the visual field (on the left-hand margin of the retina) during the time required for the attention[1] to pass from left to right over the separate word impressions, converting each in turn into a definite word perception. The time thus required is probably a function of the time required actually to speak the words. But this fading out process can hardly be assumed to take place until after the stimuli have ceased to operate. Assuming that these perceptual distinctions hold for normal reading, the suggestion is that the reading process on the perceptual side consists of a rhythmic alternation of stimulations and interpretations, each requiring a definite interval for its accomplishment. On first thought one might suppose that these two phases were correlated respectively with the two phases of eye movement, *viz.*, the period of rest and the period of movement; but owing to the extreme brevity of the latter, about .030 second[2] on an average, it is obvious that it would not afford sufficient time for the phase of interpretation, hence the necessity for the further supposition that the latter part of the period of rest is occupied with this phase of the process. A corroborating circumstance is the fact that in tachistoscopic reading the optimum exposure time is much less on the average than the reading pause in normal reading,[3] thus showing that the entire time of the reading pause is not needed for adequate stimulation. (3) A third factor which doubtless influences the result, is the character of the process of attention as independent of the area of most distinct vision on the retina. Within this area the scope of distinct attention is variable depending upon the relation of the stimulus to the individual's experience, or upon the arbitrary purpose of the subject. Seldom, if ever, in my results does it appear that the scope of distinct attention is equal to this relatively distinct retinal area, and this leaves a margin of impressions of which only those on the right hand could play any immediate part in the normal reading process, owing to our peculiar method of reading from left to right.

As to what functions the marginal impressions perform in normal reading, assuming that they are approximately represented by my

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[1] By the term "attention" I refer to the fact of conscious stress or relatively high degree of intensity of consciousness as it appears now in one, now in another portion of the conscious field without implying any particular theory of attention.

[2] Huey and Dearborn: *Op. Cit.*

[3] Dearborn: *Op. Cit.*

results, our knowledge is likewise somewhat too meagre to formulate any definite theory. Nevertheless, a sufficient number of facts have been established to warrant some tentative conclusions. In the first place the right-hand marginal impressions doubtless serve as preliminary partial perceptions of the words, which together with the factor of context, facilitate the full recognition of these impressions when they appear in the area of distinct attention at the next reading pause. Again, these impressions are essential as marginal stimuli to the eye for the reflex movement[1] which takes place between the reading pauses. They also, doubtless, assist in determining the direction and extent of the movement, thus fixing the character and size of the group of impressions included within the reading pause. That there is a correlation between the size of the area of distinct attention and that of the right-hand marginal impressions is shown by the fact that the area of the former varies inversely as the area of the latter. The constant presence of the right-hand marginal area must be of value, therefore, owing to its preparatory and orienting effect, allowing a more rapid succession of the movements, which more than compensates for the loss in breadth of clear perception entailed by the presence of these marginal impressions. The upper and lower marginal impressions probably also assist in determining the direction of the eye movement while those on the left-hand margin, come into function only upon return sweeps of the eyes in cases of mistake or in passing to a new line.

There are, however, still other factors which undoubtedly assist in controlling the eye movement. For example, the character of the recognition process as such, *i. e.*, whether it is successful or unsuccessful, is presumably the primary cue determining the character of this movement. But before this factor can become operative, and before the marginal impressions can become effective as stimuli there must intervene a feeling of satisfaction or dissatisfaction, as the case may be, depending upon the character of the recognition process.

Supplementary to these factors are the peculiar habits[2] of eye movement noticeable particularly in very rapid readers, and more or less in all readers, which tend to reduce the amount of variability in the extent of the movement between the reading pauses. This tendency, however, is never quite strong enough to overcome completely the influence of the variable size and complexity of the marginal impressions, and accordingly we always have a certain amount of variability remaining in spite of this factor. A useful function of this factor of habit probably consists in maintaining an average span for the distinct

[1] R. Dodge: "Five Types of Eye Movements in the Horizontal Meridian Plane of the Field of Regard," *Am. J. Physiol.*, 8.

[2] Dearborn: *Op. Cit.*

attention within which the least possible amount of literal analysis is required. The reading process is thus rendered more automatic, the rate and precision are increased, and the nervous expenditure is reduced to a minimum.

The reader need hardly be reminded, in conclusion, that in this study the investigation has been almost wholly confined to the purely perceptual aspect of the reading process, in which only the more habitual and automatic phases of word perception are involved. So far as concerns the higher syntheses involved in the higher interpretational phase of reading, the results of course have little, if any, immediate application. This latter phase deserves special treatment on its own account and would, of course, require other methods than those employed in this study.

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